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**DISCUSSION PAPERS IN ECONOMICS, FINANCE AND INTERNATIONAL COMPETITIVENESS**

# DOES THE TERM STRUCTURE PREDICT AUSTRALIA'S FUTURE OUTPUT GROWTH?

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**DOES THE TERM STRUCTURE PREDICT AUSTRALIA'S FUTURE OUTPUT GROWTH?**

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This paper examines whether the term structure of interest rates provides predictive power for real output growth using quarterly time series data from 1980:1 to 2002:2. The empirical results are consistent with previous studies undertaken for France, Germany and the UK as well as earlier Australian works. It is found that a 10 per cent increase in the interest rate spread between the 10-year Treasury bond and the 90-day bank bill results in approximately 4 per cent rise in GDP growth over the succeeding seven-nine quarters. This result is robust to the inclusion of two other relevant predictors in the accumulated future growth equation, namely the growth rate of M1, and the growth rate of the S&P/ASX 200 share price index. It is also argued that after the US, the interest rate spread possesses relatively more predictive power for Australian GDP growth than those for France, Germany and the UK.

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## 1. INTRODUCTION

The predictive content of the interest rate spread for future economic growth is crucial at least for four reasons. First, it is essential for private businesses as it assists them in deciding how much capacity will be required to meet future demand. Second, predicting economic activity is important for government to forecast budgetary surpluses or deficits more accurately. Third, it also aides the Reserve Bank of Australia (RBA) in deciding the stance of current monetary policy. Fourth, if the interest rate spread is sizable and it contains predictive power for real GDP growth, foreign investors will also keep coming in. There is a consensus among economists that the interest rate spread, defined as the difference between short- and long-run interest rates, enhances predictive power for future output growth. As shown below, it is widely believed that the slope of the yield curve is positively correlated with future increases in real economic activity. There is growing literature examining the term structure of interest rates' predictive content for output growth for a number of countries including Australia.

Using an annualised k-quarter ahead growth rate model, Estrella and Hardouvelis (1991) have found that a 1 per cent rise in the spread term stimulates the US real output growth by more than 1 per cent over the next 4 quarters. Lowe (1992) employs exactly the same methodology to investigate the relationship between the interest spread and future growth rates of various components of GDP. He concludes that every 1 per cent increase in the interest rate spread translates into a 0.56 per cent boost in Australian real GDP growth over the next 18 months, with the peak forecasting horizon at 9 quarters. His results suggest that "the steeper the upward slope of the yield curve, the faster will be the rate of output over the next one and a half years" (Lowe, 1992, p.26).

Alles (1995) examines the empirical relationship between the interest rate spread and future economic activity in Australia. His results indicate that the yield curve spread possesses significant power to predict "real" output growth but not "nominal" output growth. His empirical results (Alles, 1995, Table 2) are consistent with Lowe's findings. Using quarterly data from 1982:3 to 1993:3, these results show that a 10 per cent increase in one of his measures of interest spread (which is similar to that of this present study) results in about 0.5 per cent rise in Australian real GDP growth over the next four quarter. His annualised k-quarter ahead growth rate model loses its explanatory power after 2 to 3 years. On the other hand, Fisher and Felmingham (1998) employ quarterly data from 1983:1 to 1995:4 to analyse the relationship between the Australian yield curve and future cumulative growth in consumption expenditure. They conclude that a 1 per cent increase in the spread term leads to more than 0.6 per cent stimulus in real consumption growth over an eight-quarter horizon.

Cozier and Tkacz (1994) examines whether the term structure of interest contains predictive power for real GDP growth for Canada. Their result are analogous to the result obtained by Estrella and Hardouvelis (1991) for the US. Cozier and Tkacz (1994) argue that if the interest rate spread increases by 1 per cent, GDP growth will rise by 1.3 per cent one year latter. Plosser and Rouwenhorst (1994), Haubrich and Dombrosky (1996), and Dueker (1997), Estrella and Mishkin (1998), and Dotsey (1998) also thoroughly document the significant relationship between interest rate spreads and future output growth. All these studies assert that the spread contains significant information for predicting economic activity.

It is not the purpose of this paper to provide a comprehensive review and evaluation of the theoretical and empirical literature on the existence of the interest-rate spread-output-growth nexus. For a more detailed account of the literature on the theoretical underpinning of this relationship see Estrella and Mishkin (1997) and Dotsey (1998). One important approach to explain the relationship between the interest spread and output growth is what is referred to as the liquidity effect (Laurent, 1988; Bernanke and Blinder, 1990), "where a period of low short rates relative to long rates reflects the temporary liquidity effect on short rates of an expansionary monetary policy (McMillan, 2002, p.194). On the other hand, using a consumption-based asset pricing model, Lucas (1978) and Breeden (1979) argue that changes in the interest rate spread can reflect future anticipated changes in growth.

The rest of this paper is structured as follows. In Section 2 a theoretical model is postulated to examine whether the term structure of interest rates contains predictive power for real output growth using updated quarterly time series data from 1980:1 to 2002:2. The sources of data, summary statistics and the unit-root results are presented in Section 3. This section also presents the empirical econometric results and policy implications of the study. Section 4 provides some concluding remarks.

## 2. THEORETICAL FRAMEWORK

Estrella and Hardouvelis (1991), Davis and Hendry (1994), and Estrella and Mishkin (1997) employed the following k-quarter growth rate of output model to test the predictive power of the interest rate spread for future GDP growth:

$$\frac{400}{k}\cdot\left(\ln Y_{t+k}-\ln Y_t\right)=\beta_0+\beta_1(RL_t-RS_t)+\lambda Z_t+v_t \qquad (1)$$

where $Y_{t+k}$ is the level of real output during quarter t+k; RL denotes the rate of return on 10-year Treasury bonds; the 400 produces roughly an annualized percentage growth rate (4 quarters per year times 100 to make it a percent); k is the forecasting horizon in quarters; RS is the interest rate on 90-day bank bills; Z includes other information variables representing the contemporaneous measure of monetary policy (Estrella and Mishkin, 1997) or the rate of return in the stock market (McMillan, 2002).

Following above-mentioned studies only two interest rates are used to measure the slope of the yield curve. In this paper Z represents two additional variables: the growth rate of the S&P/ASX 200 share price index (P) and the M1 growth rate. A number of other monetary aggregates such as M3 and BM (broad money) have also been used in the estimation process, but the results were not satisfactory. Cozier and Tkacz (1994) have also incorporated stock prices and the money supply into their growth model in a similar way. Therefore, the following equation is specified to examine the impacts of the term structure of interest on future GDP growth:

$$\frac{400}{k} \cdot \left( \ln Y_{t+k} - \ln Y_t \right) = \beta_0 + \beta_1 (RL_t - RS_t) + \beta_2 \Delta \ln(M1_t) + \beta_3 \Delta \ln(P_t) + v_t \qquad (2)$$

Equation (2) predicts the future cumulative changes in real output growth using the slope of the yield curve, the growth rates of M1 and an aggregated share price index. Why there should be a relationship between these two variables? Estrella and Mishkin (1997) answer to this questing using the "common factor" explanation: this means that both the term structure of interest and future real GDP growth are determined by the current stance of monetary policy. For example the pursuit of a tight monetary policy by the Reserve Bank of Australia (RBA) makes the yield curve flatter, causing a slowdown in economic activity. It is argued that "expectations of future monetary tightening could be associated both with higher interest rates and lower output, especially in the short-run, and this could be thought of as future shifts in the LM curve" (Estrella and Mishkin, 1997, p.1385). Thus, one expects that $\beta_1>0$. They also argue that monetary policy is not the sole determinant of the term structure of interest rates and this is the main reason why both monetary variables and the yield curve spread term should be incorporated in equation (2). One also expects $\beta_2$ and $\beta_3$ to be positive, supporting the view that expansionary monetary policies and rising share prices provide positive signals for more economic prosperity.

Before embarking on our empirical quest, two important issues are worth highlighting. First, because the forecast horizon or k in equation (2) varies from 1 to 12 quarters ahead, one has to address the moving average error term of order k-1 resulting from the overlapping of forecasting horizons. This problem does not affect the consistency of the OLS coefficients but it definitely distorts the consistency of the OLS standard errors. In order to overcome this econometric problem and obtain consistent estimators, the standard errors of the coefficients are corrected by the Newey-West (1987) method before calculating *t*-ratios. Second, it is widely known that the use of non-stationary data can result in spurious regression results. To this end, two unit root tests, *i.e* the ADF test, and the Kwiatskowski-Phillips-Schmidt-Shin (KPSS, 1992) test, have been adopted to examine the stationarity, or otherwise, of the time series data. In this paper the lowest value of the Akaike Information Criterion (AIC) has been used as a guide to determine the optimal lag length in the ADF regression. These lags augment the ADF regression to ensure that the error term is white noise and free of serial correlation.

In addition to the ADF test, a KPSS test has been calculated for all the variables. Unlike the ADF test, the KPSS test has the null of stationarity, and the alternative indicates the existence of a unit root. The KPSS test simply assumes that a time series variable (say $y_t$) can be decomposed into the sum of a deterministic trend, a random walk, and a stationary error term in the following way:

$$y_t = \beta t + \xi_t + \varepsilon_t \qquad (3)$$

where $w_t$ (a random walk) is given by $\xi_t = \xi_{t-1} + u_t$.

One can now test for the stationarity of $y_t$ by testing $\sigma_u^2 = 0$. This test involves two steps: first one should run an auxiliary regression of $y_t$ on an intercept and a time trend $t$ and save the OLS residuals (say $e_t$) and compute the partial sums $S_t = \sum_{i=1}^{t} e_i$ ; and second, compute the following KPSS statistic:

$$\text{KPSS} = T^{-2} \sum_{t=1}^{T} S_t^2 \Big/ s^2(l) \qquad (4)$$

where $s^2(l) = T^{-1}\sum_{t=1}^{T} e_t^2 + 2T^{-1}\sum_{s=1}^{l} w(s,l)\cdot\sum_{t=s+1}^{T} e_t e_{t-s}$. Following KPSS, the Bartlett window, where $w(s,l)=1-s/(l+1)$, has been used to correct for heteroskedasticity and serial correlation. A maximum of eight lags was chosen for the lag truncation parameter ($l$) in the testing procedure.

## 3. EMPIRICAL RESULTS AND POLICY IMPLICATIONS

Table 1 presents both the summary statistics and the sources of quarterly time series data for the 1980:1-2002:2. The data set examined in this analysis comprises quarterly time series data from 1980:1 to 2002:2 on real GDP or Y (seasonally adjusted, sa, \$m in 1999 prices), the annualised interest rate spread between the 10-year Treasury bond, RL, and the 90-day bank bill, RS (RL and RS are expressed as percentage), *M1* (sa \$m), and the S&P/ASX 200 share price index or *P* (31 December 1979 = 500).

**TABLE 1**
**SUMMARY STATISTICS AND DESCRIPTION OF THE DATA EMPLOYED, 1980:1-2002:2**

| Variable | Description | Source | Mean | Max. | Min. | Standard Deviation |
|---|---|---|---|---|---|---|
| *Y* | GDP (\$m in 1999 prices) seasonally adjusted (SA) | RBA (2002) Table G10 | 122936 | 176327 | 85272 | 26987 |
| $\Delta^{k=1}\ln(Y_t)$ | GDP growth rate (fraction) | - | 0.008 | 0.033 | -0.018 | 0.009 |
| *RL-RS* | the interest rate spread (%) | ABS (2002) Table 31 | 0.20 | 4.11 | -4.92 | 1.98 |
| *M1* | M1 (SA \$m) | RBA (2002) Table D03 | 61060 | 166993 | 15341 | 42161 |
| $\Delta\ln(M1_t)$ | growth rate of M1 (fraction) | - | 0.026 | 0.111 | -0.128 | 0.025 |
| *P* | the S&P/ASX 200 share price index (31 December 1979 = 500) | RBA (2002) Table F07 | 1745 | 3431 | 484 | 879 |
| $\Delta\ln(P_t)$ | real GDP growth (fraction) | - | 0.021 | 0.196 | -0.489 | 0.087 |

An important step before estimating equation (2) is to determine the time series properties of the data. In order to make robust conclusions about stationarity or otherwise of the data, both the ADF test and the KPSS test are utilised. The empirical results of the ADF and the KPSS unit root tests are summarised in Table 2. According to both tests, all the variables appearing in equation (2), *viz.* $\Delta ln(Y)$, (RL-RS), $\Delta ln(M1)$, and $\Delta ln(P)$, are stationary or I(0). The unit root test results for $\Delta^k \ln(Y_t)$, where k=2,…,12, have not been reported here but they are available from the author upon request. Since all the variables in equation (2) are I(0), one can use the OLS method along with the Newey-West (1987) standard errors to obtain consistent estimators for $\beta_i$.

**TABLE 2**
**ADF AND KPSS TEST RESULTS 1980:1-2002:1**

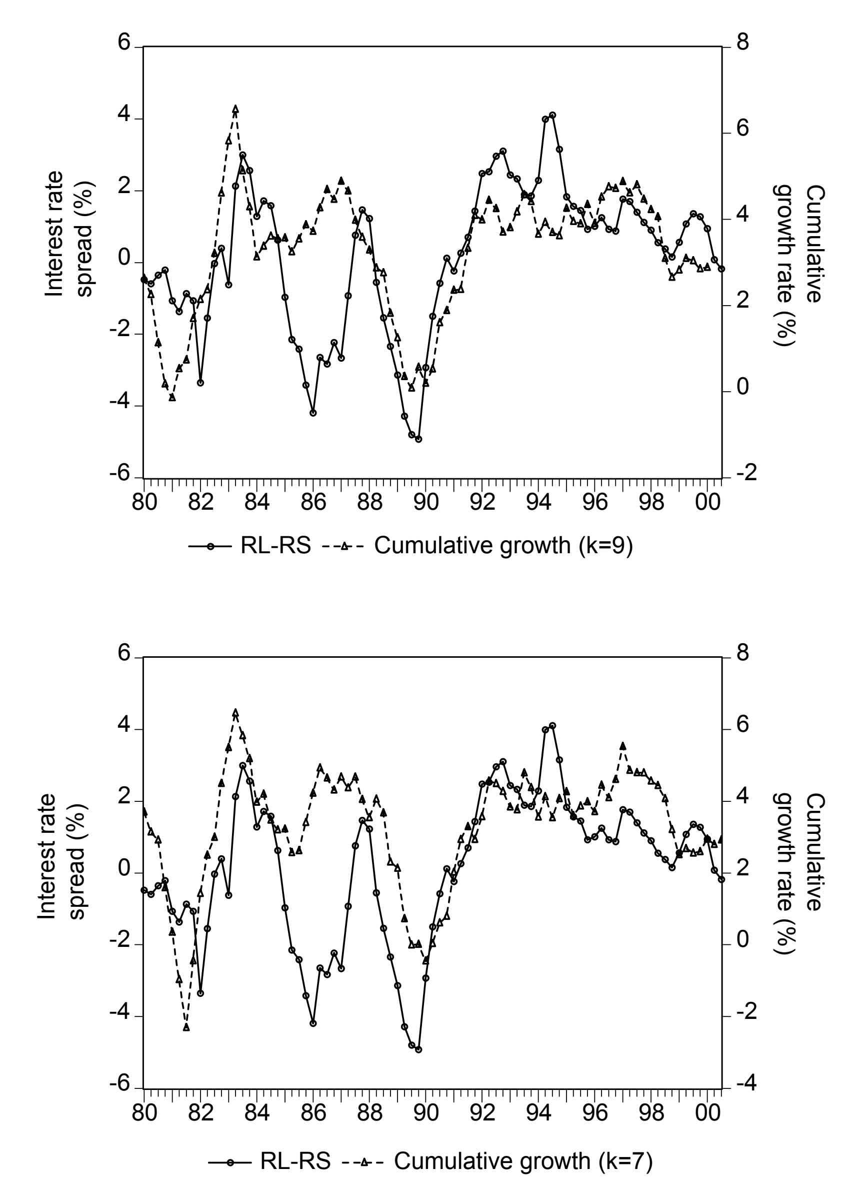
| Variable | ADF test | | KPSS Statistics |
|---|---|---|---|
| | ADF statistics | Optimum lag | |
| $\Delta^{k=1} \ln(Y_t)$ | 6.7* | 0 | 0.126 |
| *RL-RS* | -3.6* | 4 | 0.355 |
| $\Delta \ln(M1_t)$ | -6.3* | 0 | 0.094 |
| $\Delta \ln(P_t)$ | -9.1 | 0 | 0.102 |

Note: * indicates that the corresponding null hypothesis is rejected at the 5% significance level.

Before undertaking this procedure, consider Figure 1 closely. This Figure shows that the interest rate spread and the accumulated (k=9 and 7) quarterly growth rate of real output are positively correlated from 1980:1 to 2000:3. The reason for selecting the forecasting horizons of 9 and 7 quarters in this Figure will be discussed later in this section. However, at this stage it seems that there are conspicuous positive co-movements between the term structure of interest rates (proxied by RL-RS) and the accumulated future growth of real GDP. These observations are consistent with the earlier theoretical postulates and findings in the literature outlined in Section 1. An informal inspection of these two plots reveals that the interest rate spread contains sizable predictive power for real GDP growth. However, one needs to test formally to what extend the term structure can predict future changes in real output.

The empirical procedure has been to estimate equation (2) using various forecasting horizons (*i.e.* k=1,2,…,12 quarters). Following, *inter alia*, Estrella and Hardouvelis (1991), Estrella and Mishkin (1997), and Mcmillan (2002), equation (2) is initially estimated by assuming that $\beta_2=\beta_3=0$. Allowing for a forecasting horizon of up to 10 quarters ahead, the upper part of Table 3 clearly presents the estimated coefficients of $\beta_0$ and $\beta_1$ for various k values. As seen at every horizon the coefficient on the interest spread ($\beta_1$) is relatively stable, positive and statistically significant at least at the 5 per cent level, with the only exception being k=1. This coefficient varies from a peak of 0.44 at the five-quarter horizon (k=5) to the lowest value of 0.33 at the ten-quarter horizon (k=10). Therefore in a simple version of equation (2), where $\beta_2=\beta_3=0$, one can argue that a 10 per cent increase in the interest rate spread translates into 3.6 per cent rise in real output growth 9 quarters later.

**FIGURE 1**
**INTEREST RATE SPREAD AND ACCUMULATED REAL OUTPUT GROWTH, 1980:1-2000:3**




Source: Table 1.

**TABLE 3**
**PREDICTIVE ABILITY OF THE INTEREST RATE SPREAD IN THE K-QUARTER OUTPUT GROWTH MODEL**

| Forecasting horizon: k quarters ahead | $\beta_0$ | $\beta_1$ | $\beta_2$ | $\beta_3$ | $\bar{R}^2$ |
|---|---|---|---|---|---|
| 1 | 3.2 | 0.36 | - | - | 0.034 |
| | (7.1) | (1.9) | - | - | |
| 2 | 3.2 | 0.38* | - | - | 0.062 |
| | (7.6) | (2.3) | - | - | |
| 3 | 3.2 | 0.41* | - | - | 0.102 |
| | (8.1) | (2.5) | - | - | |
| 4 | 3.2 | 0.43* | - | - | 0.143 |
| | (8.6) | (2.7) | - | - | |
| 5 | 3.2 | 0.44* | - | - | 0.193 |
| | (9.4) | (2.9) | - | - | |
| 6 | 3.2 | 0.42* | - | - | 0.220 |
| | (10.2) | (3.0) | - | - | |
| 7 | 3.2 | 0.41* | - | - | 0.245 |
| | (10.9) | (3.0) | - | - | |
| 8 | 3.2 | 0.39* | - | - | 0.258 |
| | (11.6) | (2.9) | - | - | |
| 9 | 3.2 | **0.36*** | - | - | 0.259 |
| | (12.4) | (2.9) | - | - | |
| 10 | 3.2 | 0.33* | - | - | 0.253 |
| | (13.2) | (2.8) | - | - | |
| 1 | 1.70* | 0.27 | 49.41* | 7.37 | 0.128 |
| | (2.1) | (1.5) | (2.4) | (1.9) | |
| 2 | 1.66* | 0.30* | 49.85* | 10.16* | 0.267 |
| | (2.2) | (2.3) | (2.7) | (3.0) | |
| 3 | 1.98* | 0.36* | 38.45* | 10.45* | 0.325 |
| | (3.2) | (3.1) | (2.5) | (3.0) | |
| 4 | 2.30* | 0.39* | 27.67* | 8.66* | 0.312 |
| | (4.2) | (3.3) | (2.0) | (2.4) | |
| 5 | 2.45* | 0.41* | 23.17* | 7.71* | 0.353 |
| | (5.5) | (3.5) | (2.3) | (2.3) | |
| 6 | 2.55* | 0.40* | 20.18* | 6.30* | 0.353 |
| | (6.8) | (3.4) | (2.6) | (2.0) | |
| 7 | 2.66* | **0.39*** | 15.44* | 5.78* | 0.364 |
| | (8.2) | (3.4) | (2.2) | (2.2) | |
| 8 | 2.80* | 0.38* | 10.85 | 5.05* | 0.352 |
| | (10.2) | (3.2) | (1.7) | (2.5) | |
| 9 | 2.92* | 0.36* | 7.57 | 4.11* | 0.322 |
| | (11.5) | (3.1) | (1.1) | (2.2) | |
| 10 | 3.05* | 0.33* | 3.59 | 3.62* | 0.300 |
| | (13.3) | (3.0) | (0.5) | (2.2) | |
| 12 | 3.28* | 0.29* | -2.02 | 2.64* | 0.273 |
| | (16.9) | (2.8) | (-0.3) | (2.4) | |

Notes: a) the numbers insides the parentheses are the *t* ratios; b) the standard errors of coefficients have been corrected by the Newey-West Heteroskedasticity-Consistent Standard Errors & Covariance before calculating *t*-ratios.

Previous studies have used the magnitude of the adjusted $R^2$ as a proxy to measure predictive power and in-sample forecasting accuracy. Of those horizons where the term structure is statistically significant, the 9-quarter (k=9) horizon possesses the highest magnitude of the adjusted $R^2$ at 0.26, suggesting that the spread alone impressively explains 26 per cent of the variation in growth. This is the reason for including k=9 in Figure 1. It should be noted that the highest adjusted $R^2$ in other studies varies from country to country: 0.17 for the UK (McMillan, 2002), 0.29 for France, 0.40 for Germany, 0.58 for the US (Estrella and Mishkin, 1997), and 0.59 for Canada (Cozier and Tkacz, 1994).

The empirical results obtained in the present study are broadly consistent with previous works. For example, Lowe (1992) uses monthly data from 1982:3-1991:2 and his results indicate that for every 10 per cent increase in the interest rate spread, Australian real output rises by 5.6 per cent over the succeeding 18 months (4.5 quarters). As the fourth row of Table 3 shows, the present study finds that if the spread rises by 10 per cent, real GDP growth will increase by 4.3 per cent at the four quarter horizon. Moreover, the estimated coefficients for $\beta_1$ (using various k values) reported in Table 3 are consistent with the results obtained by Estrella and Mishkin (1997) for a number of other developed countries. Allowing for a forecasting horizon of up to k=12 (three years), one finds that the estimated coefficients for $\beta_1$ vary in the following order: France (from 0.46 to 0.51), Germany (from 0.39 to 0.65), and the UK (from 0.33 to 0.38). The present study has used exactly the same specification as that of Estrella and Mishkin (1997) and finds that this coefficient varies between 0.33 and 0.43. Therefore, the estimated coefficients for $\beta_1$, assuming $\beta_2=\beta_3=0$ in equation (2), are of correct sign, and order of magnitude and highly significant.

The lower part of Table 3 reports the results of estimating equation (2), where both $\Delta ln(M1)$, as a contemporaneous measure of monetary policy, and $\Delta ln(P)$, as a proxy for the rate of return on shares in stock market, are included in the model. With the exception of the 1-quarter horizon, the spread term (or RL-RS) is significant at the 5 percent level in predicting cumulative output growth up to 12 quarters (or three years) into the future. The empirical results suggest that the addition of these two variables does not noticeably change the ability of the spread to forecast output growth. It should be noted tat prior to incorporating $\Delta ln(M1)$ and $\Delta ln(P)$ into the annualised *k*-quarter ahead growth rate model, the coefficient on spread ($\beta_1$) varied from 0.33 to 0.43. After the addition of these two variables, the variability of $\beta_1$ has changed slightly from 0.29 to 0.41. Therefore, one can argue that the coefficient on the spread term has not changed from the previous results (where $\beta_2=\beta_3=0$), suggesting that the results remain robust to the inclusion of extra explanatory variables in the model.

Table 3 clearly indicates that the unrestricted equation ($\beta_2 \neq \beta_3 \neq 0$), performs quite well in terms of goodness-of-fit, most of the coefficients being statistically significant (at the 5 per cent level), and having the expected theoretical signs. It seems that the 7-quarter horizon yields the highest adjusted $R^2$ at 0.364, marginally greater than previously. This is the reason for including k=7 in Figure 1. The *M1* growth coefficients ($\beta_2$ taking various values for each k) are only significant at 1 to 7-quarter horizons, whereas $\beta_1$ and $\beta_3$ positively impact on Australia's output growth throughout.

In sum, the interest rate spread contains a reasonable amount of predictive power over the 7- and 9-quarter horizons. The empirical results suggest that a 10 per cent increase in the spread term leads to almost 3.6 to 3.9 per cent rise in GDP growth over the upcoming seven or nine quarters. The interest rate spread alone explains 26 per cent of variation in growth at the 9-

quarter horizon, whereas the three variables of RL-RS), *Δln(M1)* and *Δln(P)* explain 36.4 per cent of variation in Australia's real GDP growth. Therefore, the yield curve spread should be considered as one piece of useful information to help guide the RBA in its conduct of monetary policy.

## 4. CONCLUSION

The objective of this paper is to update the sample and explore further the relationship between the interest rate spread and the future cumulative changes in real output growth using quarterly time series for the 1980:1-2002:2 period. There is evidence that the slope of the yield curve can predict cumulative changes in real GDP for up to nine quarters into the future with an increasing adjusted $R^2$. The term structure of interest rate alone explains more than one-fourth of the variation in future output changes. This result is robust to the inclusion of two other relevant predictors in the accumulated future growth equation, namely the growth rate of M1, and the growth rate of the S&P/ASX 200 share price index. These two additional explanatory variables can also marginally enhance predictive power for future output growth.

Based on the present studies and another study by Estrella and Mishkin (1997), it can be argued that after the US, the interest rate spread possesses relatively more predictive power for Australian future GDP growth than those for France, Germany and the UK. The empirical results indicate that a 10 per cent increase in the spread term leads to almost 3.6-3.9 per cent rise in GDP growth over the succeeding 7-9 quarters. It seems plausible to argue that the term structure of interest provides a rich source of information on future output changes that monetary authorities cannot find elsewhere. Thus it is suggested that the spread term should be kept in the list of the RBA's leading indicators. The RBA can extract useful information about future output growth from the variation of the interest rate spread for the conduct of monetary policy.

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